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Veröffentlichungsversion / Published Version
Forschungsbericht / research report

Expanding the Theoretical and Methodological Framework of Social Dilemma Research

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ZUMA-Arbeitsbericht Nr. 89/16

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Abstract: In this paper five recommendations are given for expanding the theoretical and methodological framework of applied social dilemma research:

1.) We should not contend ourselves with identifying causal factors which may determine empirical subjects' decisions in social dilemmas. When looking for the ultimate causes of an observed behavior in social dilemmata, we have to explain the evolutionary selection value of the decision patterns in question; we must not contend ourselves with revealing the the psychic mechanisms which caused the observed behavior to happen.
2.) In designing our experiments, we should give more emphasis to experimental markets rather than to experimental games. In particular we should study experimental markets which allow for a dynamical adjustment, because quite often the rationality of a behavior can be empirically judged only from such a dynamical component. Such experiments will not only be theoretically richer, but will permit observing phenomena which would otherwise go undetected.
3.) The key to understanding people's decisions in social dilemmata are their expectations regarding the decisions of the other players. Therefore, a major focus of interest should be measuring these expectations of subjects in experiments, and investigating the rationality of these expectations.
4.) As soon as adjustment processes are no more equifinal (because there are many possible endpoints, which equally qualify as rational results) the rationality of individual decision making as well as of the market dynamics as a whole lies in the process itself of reaching some equilibrium. If we mean by bargaining any process by which individual players come to a convergence of wishes and offerings, then scrutinizing the rationality of the bargaining strategies which on the marketplace the agents apply is the only way to investigate the rationality of the results of the whole process.
5.) Once we adopt a process oriented notion of rationality, as outlined, we have to put the analysis of our subjects' bargaining behavior, which means the reconstruction of the bargaining strategies, applied by the players, into the center stage of experimental social dilemma research. The experimental design of choice for this analysis are bargaining games between a real subject and a group of computer simulated bargaining partners.

Cooperation within a group, which means collective efforts for the achievement of a common good, is the very core of human sociality, and is marked by two characteristics. First, if successful, it makes everyone in the group better off than if left with the alternative individualistic solution to a particular problem. Secondly, quite often it is exploitable: from a purely individualistic cost-benefit viewpoint, the best choice then is the one which allows you to enjoy the fruits of the collective effort without having contributed properly to its costs; while the worst choice is the one which leaves you alone with the costs for what is collectively enjoyed thereafter, if you spent more than would have been necessary for an individualistic solution for you alone. If we denote with V_{ij} the value of the behavior i in an encounter with behavior j, and if we denote cooperative behavior with c and non-cooperative behavior with n, then we can express these two characteristics by the following three inequalities:

$$V_{cc} \geq V_{nn} \quad (1a), \qquad V_{nc} \geq V_{cc} \quad (1b), \quad \text{and} \quad V_{nn} \geq V_{cn} \quad (1c)$$

Any social situation in which either conditions 1a) and 1b), or 1a) and 1c) are fulfilled, is a Social Dilemma situation. If all three conditions hold:

$$V_{nc} \geq V_{cc} \geq V_{nn} \geq V_{cn} \qquad (1d)$$

we have a Prisoner's Dilemma (PD), a proper subset of all Social Dilemma. Since by simple payoff manipulation either conditions 1b) or 1c) can be removed from 1d), the PD has been treated in theory as well as in empirical research as the model for all Social Dilemmata, and we will also do so. Three basic properties of any PD type of a Social Dilemma can be derived from (1d):

(i) V_{cc} is Pareto-optimal, and V_{nn} is not; but
(ii) V_{nn} is an equilibrium, and V_{cc} is not;
(iii) non-cooperation is a dominant strategy; there is no mixed equilibrium.

In Social Dilemma Research we are closer to a paradigmatical stage of the development of science than in many other areas in social psychology and microsociology. In order to get even further towards this goal we should not

only communicate to each other the results of recent experiments. We should also exchange ourselves about the fundamentals of our theoretical and experimental work, in order to come to a gradually more unified basis for both. In order to initiate such an exchange, I want to make five recommendations to aspiring Social Dilemma researchers:

I.

1. We should not contend ourselves with identifying causal factors which may determine empirical subjects' decisions in social dilemmas. When looking for the ultimate causes of an observed behavior in social dilemmata, we have to explain the evolutionary selection value of the decision patterns in question; we must not contend ourselves with revealing the the psychic mechanisms which caused the observed behavior to happen.

According to the Dutch ethologist Tinbergen, in all empirical behavioral sciences there are four principal problems associated with the question "Why?": structure, function, ontogeny and evolution.
The dimension "Structure" refers to the physical and psychic mechanisms which in an agent's body and mind produce the behavior pattern which we are studying.
The dimension "Ontogeny" refers to the development of this machinery within the agent's lifespan. In both dimensions explanations refer to the chain of proximate causal effects which finally are producing the manifest behavior pattern in question.
"Function", on the other hand, refers to the utility of the behavior in question for the agent's chances for survival and reproduction, and therefore to the utility of the physiological and psychic mechanisms producing this behavior. "Evolution" refers to the forces shaping the phylogeny of these mechanisms. In these latter two dimensions explanations are about the ultimate causation of the manifest behavior pattern we study.

The general framework of all social dilemma research is as follows: Depending on a subject's expectation about what the other players involved will do and how they will respond to this subject's own decisions, the cooperative option is preferable over the non-cooperative option, or vice

versa. According to these expectations, people will then make their decisions. These expectations may be influenced by structural factors (personality traits; life history; psychobiological factors like sex, age, endocrinological status; specific training etc.) or by aspects of the situation (history of the game; type of decision framing; dimension of uncertainty associated with decision problems etc.).
Typically the expected utilities in the sense of Neumann-Morgenstern and the stability properties of strategy combinations are either kept constant throughout the experiment or are equally modified for all subjects. Then we want to observe, how these structural or situational factors modify the subjects' decisions.

Implicit in this general setting is, that we assume all subjects to form sensible expectations and to make rational decisions, but that rationality means not exactly the same for all subjects in all situations. If we do not want to end up at the insinuation, that some people structurally are more rational than others, we have to assume that rationality indeed may advise different people to behave differently in certain situations, and that there may be differences in situations, which are not reflected in the expected utilities of the options at stake, but which nevertheless call for different choices.

Most social dilemma theory stops here, because of the confusion over the type of explanation we are looking for. What makes a Social Dilemma a Dilemma, and therefore a problem for behavioral scientists, is the dilemma between conflicting decision incentives, and not between conflicting behavior mechanisms (as in those experiments when it was tried to experimentally produce neuroses in cats: cats were offered food, when the cats reached for it, the animals were given a mild electric shock). A Social Dilemma is a rationality dilemma, and accordingly, in experimental Social Dilemma research we deal with the rationality of real subjects' decisions and not with the causality of these decisions.

Following Theodosius Dobzhansky's dictum: "Nothing in the life sciences makes sense except in the light of evolution" we should look for the evolutionary rationality of an observed behavior in such a dilemma: how it adds

to the organism's survival and reproduction chances. And likewise for interpersonal differences in observed behavior: maybe different people make different choices because maximizing their survival and reproduction chances requires them to make different choices.

Let me demonstrate this with three examples:
First take the influence of perceived uncertainty on decision making in a Social Dilemma situation. Suleiman and Rapoport (1987) have described a sophisticated experimental design entailing various levels of environmental uncertainty (net payoff is a random variable with known or unknown mean and varying variance) in addition to the social uncertainty (other players' contribution is a random variable with known or unknown mean and varying variance). Budescu et al. (1988) have applied this design in various forms of a Commons Dilemma, finding an strong impact of environmental uncertainty on subjects' behavior in Social Dilemmas: with increased environmental uncertainty people become more greedy and less concerned about the future of the common resource.
A second example: a well known effect in individual decision making, described by Kahnemann and Tversky, is that people tend to be risk-averse, if they can better their position, but tend to be risk-seeking, if the issue is how to avoid a turn of their position to the worse. As a by-product in a recent study (Mueller et al. 1987) we found, that while our subjects displayed this effect, as expected, in an individual decision making situation, this effect vanished in the Social Dilemma group decision making situation.
A third example: Einhorn and Hogarth (1985, 1986) have shown that ignorance about the probability distribution of an uncertain event (or technically speaking: ignorance about a random variable's probability distribution) adds a new dimension of uncertainty to the first-order uncertainty of not knowing the actual value, but the probability distribution of a variable. Einhorn and Hogarth have used the term "ambiguity" for this new dimension of uncertainty; in experiments people tend to treat ambiguity as additional uncertainty. It is possible that there are connections between the findings of Budescu et al. and the ones of Einhorn and Hogarth.

In all three examples, the underlying cognitive processes are closely associated: how to cognitively process risk perception. A rationality explanation in all these examples, in my opinion, would have to use a gambler's ruin model in order to show that if there is a maximal loss (death; termination of the genetic lineage):

- then getting greedy and focusing on short-term benefits may be evolutionarily the most rational strategy in a Commons situation, once environmental uncertainty rises;
- then Kahnemann's and Tversky's risk averse/risk seeking behavior may be most rational strategy agents can apply in uncertain physical environments; on the other hand, maintaining one's reputation and predictability in uncertain social environments may by far offset the advantages of this switching from risk-averseness to risk-proneness and back;
- then it can be directly demonstrated that with a greater variance of your probability of survival and reproduction chances (with their respective expectation values unchanged), the chances of death and lineage extinction within a given period of time increase (Ellison 1984).

II.

2. In designing our experiments, we should give more emphasis to experimental markets rather than to experimental games. In particular we should study experimental markets which allow for a dynamical adjustment, because quite often the rationality of a behavior can be empirically judged only from such a dynamical component. Such experiments will not only be theoretically richer, but will permit observing phenomena which would otherwise go undetected.

Several branches of the social sciences within the framework of their respective disciplines not only have developed theoretical models of Social Dilemmas, but have developed their own approaches to the experimental testing of these models. Very disturbing, however, is how contradictory the results of these innumerable studies are, depending on the choice of the experimental setting even though the core of the cooperaton problem is left unaltered. Two types of experiments on cooperation for a collective purpose

display this divergence of results, despite the identical decision problem, in an extreme manner. These two types are derived from the two most important theoretical approaches to the subject as a whole: welfare economics and the theory of games.

The first type of experiment are experimental market transactions over public goods; the other are cooperation dilemma games, of which the Prisoner's Dilemma is the most prominent example. It has been found time and again that people seem to be much less cooperation-minded in the second type of experiment than in the first one (for an extensive report, see Stroebe and Frey, 1982), despite the fact that both types of experiments embody the characteristics of a Social Dilemma, and are therefore equivalent with respect to the underlying decision rationality.

In an experimental study (Mueller et al. 1987) we could demonstrate, that the confusion over the results of the two types of experiments is mainly caused by wrongly equating Free Riding (zero contributions) in the market transaction experiments with non-cooperation in the social dilemma games. The amount of the collective good provided at the non-cooperative equlibrium, however, does not necessarily has to be zero, as we will show. Consequently, we contend that the contradictions between the results of the two experimental designs can be resolved by an public goods approach, which focuses on the distinction between two types of rational behavior, which we can label as Group-Welfare behavior versus Individual-Adjustment behavior as the general manifestations of cooperative versus non-cooperative behavior. Both types of behavior, Group-Welfare behavior and Individual-Adjustment behavior, cannot fully be understood without a prior understanding of the theory of public goods, and in particular of one of its most important results, the Samuelson/Olson Theorem, which states that in a pure market economy with solely individual incentives, the supply of public goods always tends to be suboptimal.

Private goods are characterized by rivalry of consumption and technically feasible excludability of additional consumers. So we have:

$$X_C = X^1 + X^2 + X^3 + X^4 \ldots\ldots + X^H \qquad (2)$$

where X_C is the total amount of a purely private good C in a market economy and X^h is the part of it which goes to the h-th consumer (h = 1,2...,H). In contrast, the distinctive feature of a purely public good is that it cannot be parcelled up this way, and if it is supplied to one possible consumer, it is supplied to everyone else in the consumer's social or physical neighborhood. So we can state:

$$X_D = X^1 = X^2 = X^3 = X^4 ..... = X^H \qquad (3)$$

Every consumer receives the same: i.e. the total amount X_D of the public good D. Now, what is the optimal supply of a public good as compared to a private one?

We consider an economy with a single public good, consumed in quantity G by everybody. Unless stated otherwise, we assume public and private goods to be normal goods - goods for which higher income means higher demand, and lower income lower demand. We want to determine the level of G and the allocation vector $\mathbf{x}^h \in \mathbb{R}^n$, of n private goods to H consumers (i = 1,2,..,n; h = 1,2,..,H) which maximizes a social welfare function. We define this function as follows.

Let U^h (X_i^h, G) be the utility function of consumer h, and let $\mathcal{Y} : \mathbb{R}^H \mapsto \mathbb{R}$ be $\mathcal{Y}$ $(U^1, U^2, U^3, ..., U^H)$ a twice differentiable, concave welfare function which is monotonically increasing in all its arguments (such a social welfare function is called an individualistic social welfare function, since ceteris paribus neither will a decrease in the welfare of one individual lead to an increased aggregate social welfare, nor will a higher welfare of one individual result in a lower aggregate social welfare). We want to maximize $\mathcal{Y}$ under the constraint of an aggregate production function $F: \mathbb{R}^{n+1} \mapsto \mathbb{R}$ which we define as

$$F = F(\mathbf{X}, G) \text{ with } \mathbf{X} = \sum^{H} \mathbf{x}^h, \quad \mathbf{X} \in \mathbb{R}^n$$

For maximizing $\mathcal{Y}$ - a function of several variables - under the constraint of F, we have to find a maximum of the corresponding Lagrange function:

$$\mathcal{L} = \mathcal{Y} - \lambda F(\mathbf{X},G) \tag{4}$$

λ indicating the auxiliary variable which vanishes thereafter. The first order conditions for a maximum of the Lagrangean are

$$\dot{\mathcal{L}}_{X_i^h} = \dot{\mathcal{Y}}_{U^h} \dot{U}^h_{X_i^h} - \lambda \dot{F}_{X_i^h} \tag{5}$$

and

$$\dot{\mathcal{L}}_{G} = \sum_h \dot{\mathcal{Y}}_{U^h} \dot{U}^h_{G} - \lambda \dot{F}_{G} \tag{6}$$

We can divide the h-th term of (6) by $\dot{\mathcal{Y}}_{U^h} \dot{U}^h_{X_i^h}$ since it is the same for all h's. After suitably substituting for (5), we get:

$$\sum_h \left(\dot{U}^h_G \,/\, \dot{U}^h_{X_i^h} \right) = \dot{F}_G \,/\, \dot{F}_{X_i^h} \tag{7}$$

for all i's. From conditions (5) and (7) we can derive the characteristics of the optimal allocation of public goods as well as private good in $\mathbf{X}^h$, the marginal rate of substitution must equal the marginal rate of transformation:

$$MRS^1_{ij} = MRS^2_{ij} = \ldots\ldots = MRS^H_{ij} = MRT_{ij} \tag{8}$$

for all i,j goods and every consumer h.

Condition (7), on the other hand, states that the sum of the marginal rates of substitution between the public good and any private good contained in $\mathbf{X}$

must equal the marginal rate of transformation between the public good and any private good.

$$\sum_{h} MRS^{h}_{ig} = MRT_{ig} \qquad (9)$$

for all i's. We a re now in a position to state the Samuelson-Olson theorem in a precise form:

In a pure market economy with solely individualistic incentives the real aggregate demand for any public good which is a normal good, is always smaller than the aggregate demand, at which the sum of the individual marginal rates of substitution between the public good and any private good equals the marginal rate of transformation between the public good and any private good:

$$G_{real} < G(\sum_{h} MRS^{h}_{ig} = MRT_{ig}) \quad \text{for all} \quad i \qquad (10)$$

To see why, let us look at the way individual consumers make their adjustment decisions in the economy. The level of consumption of any private good depends solely on the individual's preferences and two parameters: the budget constraint and the price vector. In contrast to this, the individual consumption level of the public good depends also on the adjustments made by all other consumers. But if the individual consumer makes his adjustment decisions in the same way as he does in the private good case i.e. if other consumers' decisions are taken as given and unaffected by one's own expenditures the total supply of the public good will be suboptimal.

To show this, we simplify our model to a two-goods economy with a public good, purchased by consumer h in quantity G^h, which comes in quantity $G = G^h$ to everyone; and a private good X^h, which is assumed to be some sort of a substitute for the public good or simply a numeraire. We assume that all consumers have identical preferences and endowments M^h. For reasons of simplicity, we further assume that the public good can be produced at the constant marginal cost c_m, which is just another way of saying that it can

be purchased at constant unit price. Then each consumer wants to maximize his utility function $U^h: \mathbb{R}^2 \to \mathbb{R}$

$$U^h(X^h,G) = U^h(X^h,G^h + \sum_{k \neq h}^{H} G^k) \tag{11}$$

such that

$$M^h = X^h + c_m G^h$$

The Lagrangean function is then:

$$\mathcal{L} = U^h(X^h,G^h + \sum_{k \neq h} G^k) + \lambda((M^h - X^h - c_m G^h) \tag{12}$$

Since each consumer treats the purchase of the public good by all other consumers as given, we have the following first order conditions:

$$U^h_g / U^h_{X^h} = MRS^h_{x,g} = c_m \tag{13}$$

Each consumer adjusts his consumption bundle in a way that his own MRS equals the MRT. The supply of the public good which results from purchases made by other consumers affects the individual consumer like a linear shifting of his budget line by a constant factor to the right. The family of these new budget lines is given by:

$$X^h = M^h - c_m G^h + c_m \sum_{k \neq h}^{H} G^k, \quad X^h \leq M^h \tag{14}$$

(Remember that G^h is a variable, but $\sum_{k \neq h}^{H} G^k$ is a constant.) If we let $\sum_{k \neq h}^{H} G^k$ gradually increase from zero, for each of its possible values there will be a point on the shifted budget line which meets condition (13). If we connect all these points, we get the individual Nash-reaction curve (Figure 1).

- insert Figure 1 here -

Under the usual assumptions about indifference curves, the individual Nash-reaction curve has a positive slope. Now, if $\sum_{k \neq h}^{H} G^k$ is not fixed, which point on the individual Nash-reaction curve will be chosen in an overall equilibrium? For consumers with equal endowment and equal preferences, it must be the same point on their individual Nash-reaction curves, and this point P must meet the condition:

$$X^h = M^h - c_m G/H \qquad (15)$$

for all h's. This point P on the Nash-reaction curve is the Nash-equilibrium, since any unilateral deviation from it will diminish the respective consumer's utility. But P is certainly not a Pareto-optimal supply level. Since every point on the straight line defined by (15) is feasible, the optimal allocation would be P' where

$$U^h_g / U^h_{x^h} = c_m / H \qquad (16)$$

since the marginal cost of transformation of the private into the public good now is split equally among the H identical consumers. Given convex indifference curves P' necessarily lies to the right of P (Figure 2).

- insert Figure 2 here -

If we use the ratio G(P)/G(P') as a measure for the degree of the suboptimality of supply, we find that the greater the number of consumers involved, the greater the degree of suboptimality will be, which is one of the important consequences of the Samuelson/Olson Theorem.

We may now devise two different types of decision rationality, and consider which sort of reaction the two different types of decision rationality in our model prescribe for A, if B - by which we indiscriminately mean the rest of the group - changes his contribution. Put more formally, we will consider

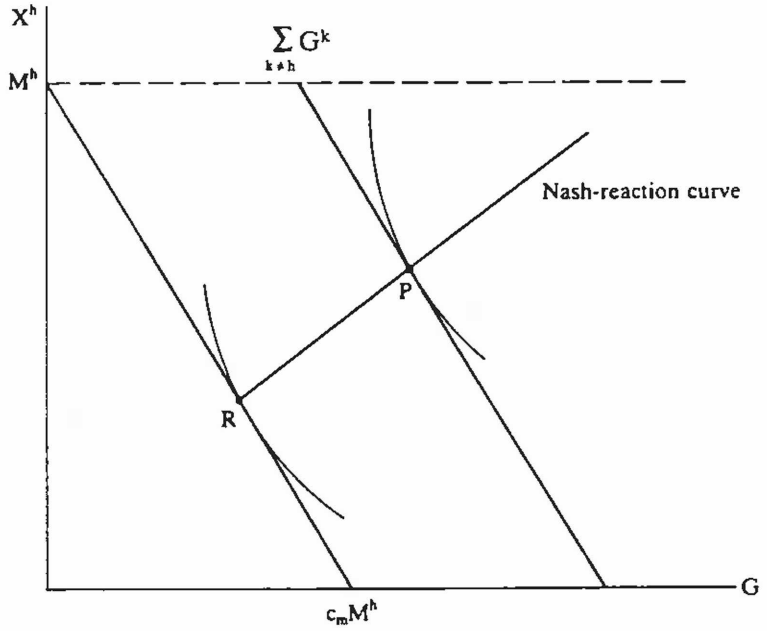

FIGURE 1. The individual Nash-reaction curve
(taken from Mueller et al. 1987)

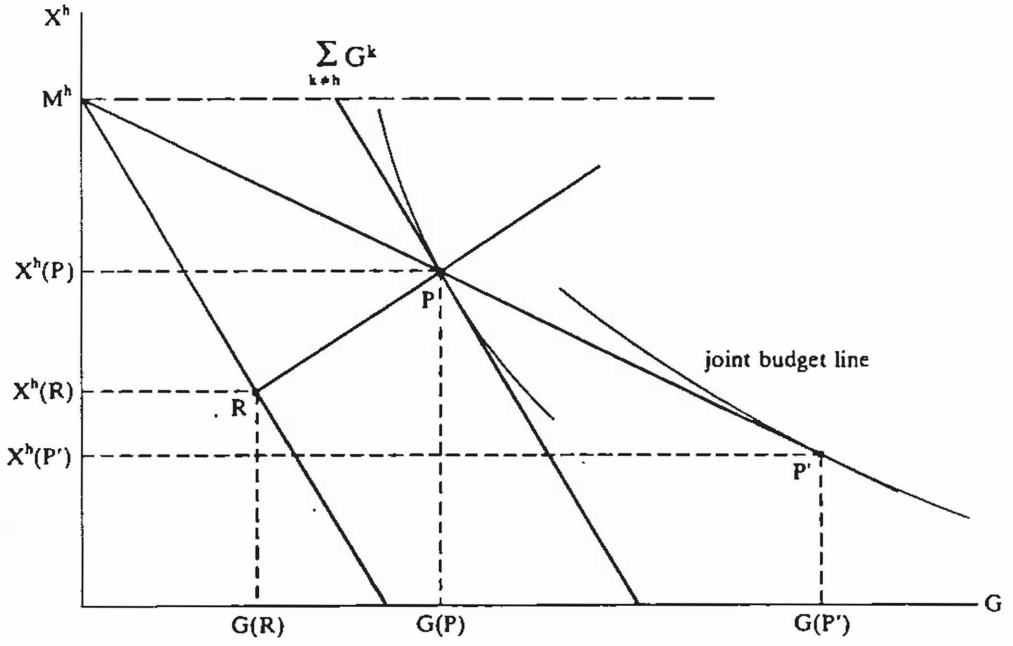

FIGURE 2. Nash-equilibrium P and social optimum P'
(taken from Mueller et al. 1987)

A's behavior away from the Nash-equilibrium or the social optimum, respectively.

For both types of decision making, the point of departure is A's individual demand R (see Figure 3), if no other agent is on the stage.

- insert Figure 3 here -

If the individual consumer makes his adjustment decisions in the same way as he does in the private good case i.e. if other consumers' decisions are taken as given and unaffected by one's own expenditures, we may call this an Individual-Adjustment behavior. Starting from R, an Individual-Adjustment behavior prescribes A to decrease his expenditure for the public good, the more B spends for it. Whenever B cuts back on his expenditure, A will again increase his contribution up to the amount he spends at R. A's reaction curve moves from R on upwards - indicating that as he decreases his expenditure for the public good, the more $\sum_{k \neq i}^{n} G^k$ increases - until T, from where on A will make no more contributions to the public good, since he is content with what he gets for free. The Nash-equilibria - P_1 or P_2 in Figure 3 - are the points where the joint budget line (15) intersects the individual Nash-reaction curve. Under the assumptions made, the slope for the Nash-reaction curve is positive (non-negative).

A Group-Welfare behavior, on the other hand, acts as if the expenditures of all consumers were tightly linked together, as if one single agent - acting as a benevolent dictator - determines the total demand and the individual expenditures for the public good on the basis of the individual demand functions. If all members of a group have adopted such a behavior, each member acts as if his individual demand also determines the total demand of the group. We know that only under these conditions a pareto-optimal supply level can be achieved. For the moment we will disregard the inherent exploitability of this behavior, which in an environment of Individual-Adjustment strategists would dwarf all attempts to achieve this goal, and assume that B has adopted a Group-Welfare behavior as well. In the case of Group-Welfare behavior, A's reaction below the social optimum would be completely different. The public and the private goods in our model are normal

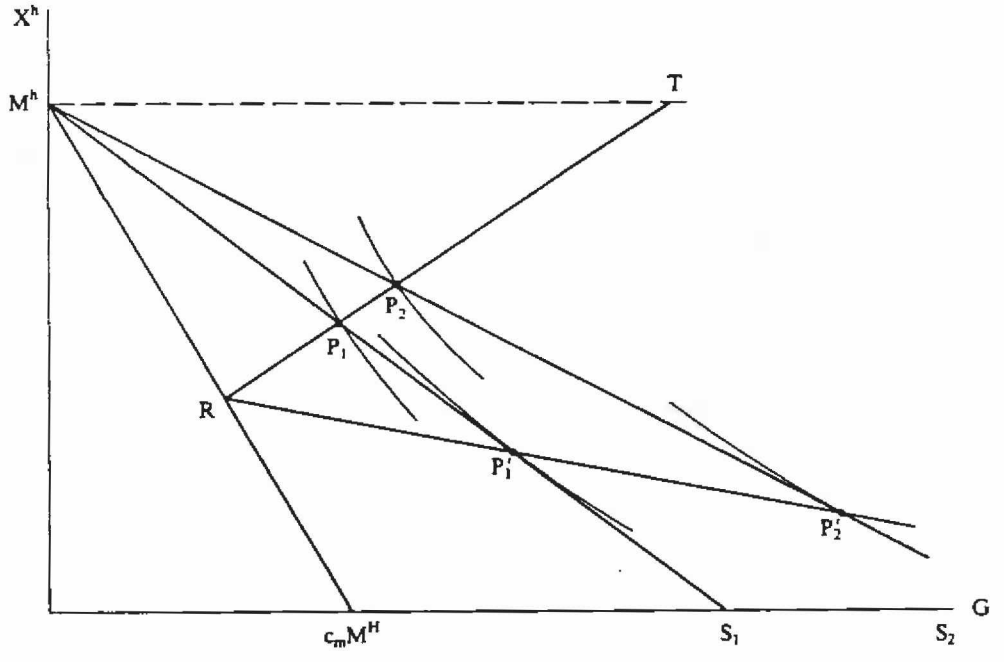

FIGURE 3. Nash-reaction curve and Group-Welfare-reaction curve (taken from Mueller et al. 1987)

goods, and the private good is specified as a substitute (or a numeraire), which means that the cross elasticity of demand for the private good is positive (non-negative). Therefore, an increased contribution to the public good by B will cause A to increase his contributions as well - up to the social optimum at P'. We can also conceive of a reaction curve of A in this case. The effect of B taking an increasing interest in the public good will be perceived by A as a counter-clockwise move of his budget line from S_1 to S_2 (Figure 3). Connecting all the resulting social optima of A - P'_1 and P'_2 in Figure 3 - gives us A's reaction curve for the Group-Welfare behavior case. Under the assumptions made, the slope for the Group-Welfare-reaction curve is negative (non-positive).

There is an immediate conclusion from these theoretical considerations for determining the behavior type a subject applies in a certain situation. To categorize a subject we need to know his individual allocation R between the public and the private good, as long as there are no other agents on the stage, and then his contribution to the public good in the group situation. In order to determine the Nash-equilibrium P and the social optimum P', we need to know the subject's individual demand function, which in general may not be observable. But we can expose the subject to varying levels of contributions made by the other players, forcing our subject into a dynamical adjustment process, and then observe the slope of the resulting reaction curve. If the slope is negative, we can categorize the subject as a Group-Welfare type. If the slope is positive, we may categorize the subject as an Individual-Adjustment-type.

Applying the findings from the public goods theory to cooperation games, in particular the Prisoner's Dilemma, is not difficult. Mutual cooperation in the Prisoner's Dilemma, can be equated with the Pareto-optimal result of mutual Group-Welfare behavior, and the suboptimal Nash-equilibrium in the game is equivalent to the suboptimal Nash-equilibrium in the economic transaction situation. Likewise, Individual-Adjustment behavior is a dominant strategy in the economic transaction situation. It is, on the other hand, obvious, that in the public goods model noncooerative behavior not necessarily results in zero-expenditure for the public good, which explains the

difference between the free-riding frequency in experimental markets, and the noncooperation frequency in cooperation games, as outlined above.

The Prisoner's Dilemma is a special case of a public goods situation, which is not only a more general, but also a richer model for the cooperation problem. All results from the public goods model are applicable to the Prisoner's Dilemma game, as far as they can manifest themselves there at all, but not conversely:
In the Prisoner's Dilemma, since the moves in the game are treated as cost free, there is no budget constraint. We implicitly assume all players to have identical individual aspiration levels R, from which the reaction curves to the contributions of the other players take their departure. But the individual aspiration level cannot explicitly be considered in the experimental game, since we have no budget constraint. Second, while the public goods situation allows continuous choices, the experimental game allows only binary choices.

We may conclude from this, in investigating the rationality of cooperative behavior, that we should switch from analyzing the occurrence of free-riding versus non-free-riding to analyzing the occurrence of Individual-Adjustment behavior versus Group-Welfare behavior as indicators of non-cooperative, non-social behavior versus cooperative, social behavior. Cooperative behavior requires much more than simply avoiding free-rides, or even cheap rides, since one can spend more than anyone else and still be absolutely uninterested in what would be the social optimum for the group. Distinguishing free-riding or cheap riding from non-free-riding nurtures the notion that free-riding is a pathology, a deviance from the norm of non-free-riding. Focusing instead on the suggested distinction between Individual-Adjustment behavior versus Group-Welfare behavior makes it clear that both represent, in some way, types of rational behavior, and only rational expectations about the social cohesion of the action context determine which one to prefer.

These rational expectations are the key to understanding the evolution of cooperation. They do not simply refer to a probability distribution over other people's future behavior moves. Experiments in which real subjects

played the Prisoner's Dilemma or related games against a simulated, pre-programmed partner showed indeed that a large proportion of subjects tended to exploit unconditionally cooperative behavior (as an overview see Colman, 1982: 123f. and Isaac et al., 1985).

Political philosophers have always been aware that only the expectation of conditionally cooperative behavior - conditional upon the partner's demonstrated cooperativeness - can elicit stable cooperative behavior. This reciprocity of reward and retaliation has been made the crucial point of all formal models described in the literature on the evolution of cooperation (Grofeman and Pool, 1976; Smale, 1980; Axelrod, 1981, 1984; Axelrod and Hamilton, 1981). A central result from this literature is that the higher the social cohesion - namely:
(i) the expected length of interaction sequences,
(ii) the reliability of information about other players' actions,
(iii) the certainty of rewards and retaliations
- the greater the chances for mutually stable cooperation to emerge. The obvious model for studying the effects of various degrees of social cohesion is iterated games with an indefinite number of iterations (supergames). Every game or market transaction as analyzed above would be an elementary game of such a supergame.

In order to be evolutionarily successful, Group-Welfare behavior in the elementary games must be an equilibrium strategy in the respective supergame. The fascinating thing here is that continuous Group-Welfare behavior in elementary games can be an evolutionarily stable Individual-Adjustment behavior in the supergame. The conditions under which this can occur are scrutinized in the literature cited.

From the subjective perspective of the individual decision-maker, the optimal choice in supergames hinges on his rational expectations concerning the social cohesion of the group. If the social cohesion, including mutual information, of the group is high, Group-Welfare behavior on the part of the others will stimulate me to behave in the same way. If I know that the others will display Group-Welfare behavior if and only if I display Group-Welfare behavior, then it is rational to actually display Group-Welfare

behavior. If the social cohesion of the group is low, and I cannot expect that the others will display Group-Welfare behavior if I display Group-Welfare behavior, then it is rational to display Individual-Adjustment behavior. An experimental expression of the reciprocity of the rational expectations can be found in the high correlation between the self-rated behavior type of subjects and the behavior type attribution subjects make with regard to the other players in the group (Kelley and Strahelski, 1970a, 1970b, 1970c). The two decision behavior types - Individual-Adjustment behavior and Group-Welfare behavior - are more than just theoretically derived extreme positions, between which, in reality, every mixture is possible. The occurrence of the two clearly distinguishable behavior types of 'competitors' and 'cooperators' can be explained on theoretical ground: any equilibrium between non-cooperative and conditionally cooperative strategies in cooperation games is unstable (Mueller, 1986, 1987).

III.

3.) The key to understanding people's decisions in social dilemmata are their expectations regarding the decisions of the other players. Therefore, a major focus of interest should be measuring these expectations of subjects in experiments, and investigating the rationality of these expectations.

Measuring of subjective probabilities raises difficult methodological and theoretical problems.

a) Axiomatic probability theory expresses the probability of an event or a set of events by a real number on the closed interval between zero and one. The probability concepts of natural languages (possible, probable, improbable, a real chance that ...), on the other hand, have a vague meaning. Specific research overwhelmingly has demonstrated that ascribing of appropriate (in terms of axiomatic probability theory) numerical values to probability concepts of natural languages varies extremely not only between subjects, but also within subjects over time (see as an overview Wallsten et al. 1986). In addition, the probability concepts of natural languages widely overlap in these numerical ascription.

A solution to this problem can be found in ideas developed by Watson et al. 1979, Zimmer 1983, and Wallsten et al. 1986. The meaning of natural language probability concepts is expressed as an argument of membership functions. Membership functions have been introduced in the theory of fuzzy sets, and one defined as a maping of every element m of a set M into the closed interval between zero and one. The argument of this maping expresses the degree to which this element m of N belongs also to another set N. If m certainly is not a member of N, then the membership function has the value zero; if m certainly is a member of N, the value is one; values are in between otherwise.

A membership function can serve to express how well - in the judgement of a subject - the points on the closed interval between zero and one represent a certain natural language probability concept. In a series of technically very sophisticated experiments Wallsten et al. (1986) have shown, that the measuring of natural language probability terms with such membership functions is at least within subjects relatively stable over time.

We should energetically utilize these ideas for experimental social dilemma research. A first step would be to test whether natural language probability terms mean the same if applied to physical and to social uncertainties.

b) Subjects with a formal education, even with a specific mathematical training have been shown to be surprisingly inconsistent in cognitively processing subjective probabilities, committing all sorts of errors - as seen not only from classical expected utility theory, but also from axiomatic probability theory. Notable examples of violations of the latter are the insensitivity to prior probability of outcomes or to sample size, the misperception of chance in small samples or of the effects of regression, or the biases in the evaluation of conjunctive events. (According to axiomatic probability theory, for $A \neq B$, $p(A \cap B) < p(A), p(B))$. This line of research, however, for which Kahneman and Tversky stand as the most prominent representatives (Kahneman et al. 1982) has not developed a theory yet why people are behaving that way.

The path towards such a theory may be opened by the observation that subjects, applying certain general rules of conversation (be specific, be relevant, be new etc.) tend to interpret given probability attributions on the most specific level possible. (Such rules were first formulated by Grice 1975. An application to probability reasoning can be found in Hilton 1988).

Let, as an example, a subject be given some information about emotional and personal qualities of a fictitious person called Fritz, and then ask the subject for the probability that Fritz is I) "a lawyer" or II) "a lawyer and an activist in leftist organizations". Clearly, $p(I) \geq p(II)$ according to axiomatic probability theory, but not if subjects interpret (I) - in the light of the information given in (II) - as "Fritz is a lawyer and not an activist in leftist organizations".

In general, if people interpret $p(A)$ - in the light of the possibility of the event $(A \cap B)$ - as $P(A \cap B^C)$, then it is not impossible that subjects indeed estimate $p(A) \leq p(A \cap B)$ (Morier and Borgida 1984).

If it could be demonstrated also for other areas of alleged logical mistakes in probability reasoning, that these mistakes vanish as such once we assume that people process the given information according to these general rules of conversation, then again we should look for the evolutionary rationality of these general rules of conversation, as the key to human reasoning and decision making in this field. A sensible first step could be again finding out whether subjects differ in their respective probability reasoning with regard for their social or their physical environment.

In addition, there is a principal obstacle to any measurement of expectations, which has been the game theoretical centerpiece of the "rational expectations" revolution in macroeconomics.
Let us assume that a player A has correct expectations concerning the strategies which the other players intend to apply. The expectations are, technically speaking, subjective probability distributions about the choice of strategies by the other players. From these probability distributions the rational choice of one's own strategies can be derived. If, however, the other players know player A's subjective probability distribution, they will

stick to their original choice (the one expected by A) only if their original choice is at the same time an equilibrium strategy and a pure strategy. The reason for this is that to every fixed choice of strategies by another player there exists a best reply strategy for A from A's available set of pure strategies, which yields to A at least as much as every possible mixed equilibrium strategy.

That means: in any situation which does not unequivocally call for a certain course of action, knowledge of my subjective expectations concerning other players' actions may dramatically alter exact those actions to be taken by other players.

The central message of the "Rational Expectations" revolution in macroeconomics refers exactly to this: agents on the marketplace form expectations about the present expectations and future actions of others; these expectations can efficiently neutralize the future actions taken by others, or may lead to consequences of these future actions which were not intended by their initiators. The better informed agents are, and the better their foresight is, the less effective, for example, any government or central bank interventions on markets might become.

Everybody knows from one's own life experience, that there are expectations which are more likely to come true if you communicate them ("One day you, too, will betray me") while there are others, which are less likely to come true if you communicate them ("In five years from now, I will be sitting in your chair, boss"). In all those cases it is rational not to communicate one's true expectations. In accordance with this one can experimentally observe, that subjects in social dilemma situations, after being questioned about their expectations concerning future decisions by other players, change their own decisions in a consistent way thereafter (Sniziek 1988).

This poses a serious methodological problem for the designing of our experiments. In many cases, I suspect, we would be well advised, to treat our subjects' expectations as unobservable variables, because any effort to observe them may substantially alter them.

IV.

It is the basic conviction of classical microeconomics that, given perfect competition and perfect information, there is a unique equilibrium for every firm and every private household, which unequivocally determines the choices a rational decision maker might want to make in order to maximize his utility. Things change, however, once we turn to non-stationary markets or to markets with incomplete competition or incomplete information.
In markets with incomplete information, i.e. if not all agents on the marketplace have the same information, there can be many, or even a continuum of equilibria. As an example: Let us assume that potential employers cannot assess the actual abilities of an individual employee, all they can do is taking notice of the employers formal educational achievements. Every employee is paid according to the productivity of an average person of his or her formal education. If there is also a market for educational services, then in the market equilibrium prices and supply of these services will be such that the net value of all levels of formal education (gross life income minus cost of the education) is the same. Given such a market equilibrium, every individual demand for education is in the household equilibrium: for whatever investment in his or her education a young person opts, his or her life net income will be the same (The empirical facts, by the way, do not support this conclusion).

The more equilibria there are, the smaller is the explanatory value of the classical rational choice model, and with a continuum of equilibria this value has vanished altogether. Given incomplete or non-stationary markets knowledge of market prices alone does not suffice to guarantee rational choices. A monopolist or oligopolist, for example, must not only know factor prices and the prices of his products on the market, he must know the demand and production functions of all consumers and factor suppliers as well, in order to make a rational decision on the optimal level of production.

In non-stationary markets present prices are no unbiased estimators of future prices. Under these conditions, perfect knowledge of future prices requires that the agents have a correct and complete model of the economy in their heads. If they don't, and if the models which they have in their

heads, differ from each other, again there may be a multitude or even a continuum of market equilibria.

The consequences of all this are clear: The classical rational choice model has not denied that individual decision making and collective approaching of equilibria are not instant events, but time-consuming processes. But it neglected the process character of rational choices for if the end point of such a process is given, the single steps this process may take are irrelevant.

In this viewpoint, there is no need either to look into the strategies agents apply in approaching an equilibrium, be it by explicit or implicit bargaining, or by individually finding out, what the best price is for one's products. Even if there are different paths such adjustment processes take, they are equifinal.

4.) As soon as adjustment processes are no more equifinal (because there are many possible endpoints, which equally qualify as rational results) the rationality of individual decision making as well as of the market dynamics as a whole lies in the process itself of reaching some equilibrium. If we mean by bargaining any process by which individual players come to a convergence of wishes and offerings, then scrutinizing the rationality of the bargaining strategies which on the marketplace the agents apply is the only way to investigate the rationality of the results of the whole process.

We have to admit that present bargaining theory by no means provides the well-developed concept of a process rationality which we would like to have for the designing of our experiments. This is so mainly because the various approaches within bargaining theory agreed in one thing: taking as the criterion for any bargaining principle's efficiency not it's procedural stability, it's dynamic dominance over competing bargaining strategies, but instead, whether it maximized the final output. Given the usual assumptions on preferences and utility functions, the equilibrium which maximizes the final output of a bargaining process then is unique.

This general way of approaching the problem neglects the central feature of bargaining. In a complex setting it is nonsense to judge the efficiency of a bargaining strategy by whether it leads to the unique optimal outcome. How can one determine this one outcome, even in retrospective? How finely tuned is it? What really matters is, that a bargaining strategy leads to an acceptable outcome, which meets certain minimal requirements, and accomplishes this in a robust way, which cannot be beaten by alternative bargaining strategies.

Any bargaining situation is characterized by the indeterminacy of the outcome. If we have a multiple or dense set of equilibrium points, then a theory of bargaining should explain, how well certain bargaining strategies are doing against each other, which bargaining strategies do reach a specific equilibrium point? What use can be made of a bargaining strategy which can reach this specific equilibrium point, when paired against some strategies, while it is hopelessly outsmarted by some other strategies, even if the latter benefit their players less well.

But this exactly characterizes the axiomatic approach which from the onset on until very recently has dominated bargaining theory. This approach can be summarized as follows:

There is a group of n agents, and a bargaining problem: in a given situation the agents have some alternatives, available through some joint action. Any alternative yields agent i utility U_i, with $0 \leq U_i \leq U_{i,max}$. The agents' preferences over their alternatives conflict, which is just another way of saying that there is a multitude of equilibrium points in this situation. If we allow mixed strategies, then under usual assumptions we have a convex set S in $\mathbb{R}^n_+$ with the Pareto-optimal part S' of the boundary of S as the set of all possible results of the bargaining process.

A solution of this bargaining problem is a function, which selects one particular result - a Pareto-optimal equilibrium point - from S', which represents an "acceptable balance between the agents' respective aspirations and sacrifices" (Thomson 1985, 235), and which therefore is the recommended optimal alternative.

Clearly the criteria of what the recommended optimal alternative should be are not derived from the initial properties of the bargaining problem, they are independently and exogeneously added to it. Several such criteria for solutions have been considered in the literature, among them:

- The Nash solution N(S') which uniquely maximizes $\prod^{n} U_i$
- the Kalai-Smorodinsky solution K(S'), which is the maximal feasible point in S' on the line, which connects the origin to the "point of milk and honey" a(S) where for each i, $a_i(S)=U_{i,max}$.
- the egalitarian solution with $U_i = U_j$ for all i and j, and $U_i, U_j = S$. (see Figure 4)

- insert Figure 4 here -

This axiomatic approach (Thomson 237) in bargaining theory suffers from three basic flaws:

1.) The recommended unique result is an equilibrium, but getting there is not necessarily a dominant strategy for all agents. Therefore agents have to enter a binding agreement on actually enforcing the recommended result. This in turn presupposes an institutional context, in which binding contracts are enforcible. This precondition, however, can hardly be assumed in every natural setting.

2.) All the mentioned criteria - Nash, Kalai-Smorodinsky, egalitarian - implicitly presuppose that interpersonal utility comparisons are meaningful. Decades of dispute have taught us, that there is no hope of ever defining an absolute measure of interpersonal utility. All we can hope for is a relative measure, like fitness in biological evolution theory. But then diminishing other players utility ipso facto increases one's own utility, and vice versa, with the effect that the whole notion of Pareto-optimality would have to be redefined.

3.) The third and most serious shortcoming is the one we already mentioned. Even if we could satisfactorily justify a criterion which uniquely defines an optimal bargaining result, why should bargaining strategies, which yield

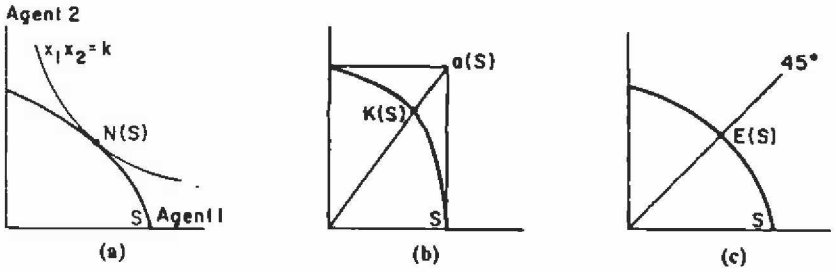

FIGURE 4.

a) Nash-solution;

b) Kalai-Smorodinsky solution;

c) Egalitarian-solution.

(taken from Thomson 1985)

this result, at the same time necessarily be resilient against all other alternative bargaining strategies. But this robustness is crucial in a world, in which evolutionary success hinges not on getting most in absolute terms, but rather on getting more than your competitors.

The other important approach in bargaining theory, the strategic approach, enjoys several advantages over the axiomatic approach. Rather than recommending an outcome, this approach recommends a strategy how to proceed step by step in a sequence of offers, and decisions to accept or reject these offers. But most models within this approach as still stuck halfway from the axiomatic theory of bargaining to a genuinely process oriented theory of bargaining, which looks for the efficiency of bargaining in the path the bargaining sequence takes, and not in it's final results.

Probably the best known of these models is the Zeuthen-Harsanyi model of bilateral bargaining: In a bargaining process players 1 and 2 either reach an agreement A or a conflict C arises, with payoffs $U_i(A)$ or $U_i(C)$, respectively, i = 1,2.

Bargaining proceeds stepwise, at step k player 1 offers an agreement A_1^k, and player 2 offers an agreement A_2^k. We assume these offers to be meaningful, i.e.

$$U_i(C) < U_i(A_j^k) < U_i(A_i^k) \qquad (17)$$

i, j = 1,2 und $i \neq j$.

Each player prefers his own last offer over the last offer of the opponent player. Each player, however, makes only offerings, which benefit also the other side at least as much as the conflict outcome.

As long as $A_1^k = A_2^k$, each player i has three options for step k+1:

a) he can repeat his last offer A_i^k;
b) he can accept the opponent's last offer A_j^k;

c) he can come up with a new offer A_i^{k+1} which benefits himself less, but the opponent more than A_i^k:

$$U_j(A_i^k) \; < \; U_j(A_i^{k+1}) \; < \; U_j(A_j^k) \qquad (18)$$

and

$$U_i(A_j^k) \; < \; U_i(A_i^{k+1}) \; < \; U_i(A_i^k) \qquad (19)$$

A new offering of this kind is called a concession.
Step k+1 may result in the following:

aa) no player makes a concession, bargaining is terminated, and conflict arises;
ab) one of the two players accepts the opponent's last offer;
bb) both players accept the respective opponent's last offer, an eventual surplus is split up among the players according to some rule (f.e. the rule of equality);
ac) the bargaining process moves toward step k+2;
bc) this case leads to the same result as bb);
cc) the bargaining process moves toward step k+2.

Zeuthen's principle tries to answer the question, when you - in cases ac) and cc) - should make a concession at step k+2, and if so, of what size, and when you should make no concession.

According to Zeuthen, in general you should make a concession, if you should be less willing to terminate the bargaining process:
If player i accepts player's j last offer, bargaining is terminated with payoff $U_i(A_j^k)$. If player i insists on A_i^k, player j can either terminate the bargaining process - with payoffs $U_i(C)$ and $U_j(C)$ - or he can accept A_i^k with payoff $U_j(A_i^k)$. Let us assume that player i expects player j to terminate the bargaining process at this step with probability $p_j(i)$. Then a reasonable player i will insists on his own last offer A_i^k, only if

$$(1-p_{ji}(i))\; U_i(A_i^k) + p_j(i)\; U_i(C) \; > \; U_i(A_j^k) \qquad (20)$$

i.e. if

$$p_j(i) = r_i < (U_i(A_i^k) - U_i(A_j^k))/(_i(A_i^k) - U_i(C)) \quad (21)$$

This subjective probability $p_j(i) = r_i$ indicates the maximal risk player i should be willing to run, if he considers enforcing an agreement on the basis of his last offer. At the same time, r_i is a measure for player's i incentive, to prefer the risk of conflict over the result of his own giving in.

Zeuthen's principle advises player i to make a concession if $r_i < r_j$, and to insist on his last offer, if $r_i > r_j$. If $r_i = r_j$ then both should make concessions at step k+2.

Zeuthen's principle does not tell anything about the size of eventual concessions.

The appeal of Zeuthen's principle stems not at least from the fact that it allows to realize possible gains in a bargaining situation step-by-step, that is, no binding contracts are necessary in order to implement the terminal solution (as it is the case in the axiomatic approach models).
Zeuthen did not care about justifing the efficiency of his principle, which he thought to be intuitively convincing. Harsanyi (1977) was able to demonstrate that if correctly applied by both players, Zeuthen's principle leads to Nash's solution to the bargaining problem (see above).

Any bargaining model must take into account the possibility that the bargaining process is terminated - by a miscalculation of the players or some outside world event - before the Pareto-front is reached. We should expect from an efficient bargaining strategy that it is sequentially rational in the sense that it is not dominated by some other bargaining strategy at any time during the bargaining process (see Cramton 1985, who defines sequential rationality slightly differently). It has not, however, been demonstrated that Zeuthen's principle is sequentially rational.

Rubinstein (1982) has devised a simple bargaining model which meets this objection. There is a cake of size 1, if the two players 1 and 2 agree on a partition of the cake, they receive their agreed share. If they fail to agree, they get nothing. Obviously, any partition of the cake is an equilibrium. The bargaining process goes as follows:

At time 0 player 1 proposes that a share of size x goes to him, player 2 accepts or rejects this proposal. If player 2 does not accept, at time 1 it is player's 2 turn to make a proposal which player 1 can accept or reject, and so on.
An important new aspect of the model is that in order to provide some incentive for the players to reach an agreement in time, the payoff to players is their agreed share multiplied with some discount factor d_1^t and d_2^t, respectively, with $0 < d_1^t, d_2^t < 1$ for all t. These discount factors reflect the players' impatience, or their valuation of time per se.

A strategy in this bargaining game is a rule which prescribes as proposal/reply sequence as a function of the history of the bargaining process up to that point. Rubinstein (1982) could show that in this bargaining game there is a partition of the cake which is a subgame perfect equilibrium, namely player 1 receives a payoff $(1 - d_2)/(1 - d_1d_2)$ and player 2 receives $d_2(1 - d_1)/(1 - d_1d_2)$. The apparent "unfairness" of this solution (for $d_1 = d_2$, player 2 receives less than player 1) can be disposed of by a rule that a coin is tossed in order to determine who starts the bargaining process.
Subgame perfectness means for player 1 as well as for player 2: proposing this partition is an equilibrium strategy not only for the original bargaining game but also for every subgame of it. Thus, this strategy is sequentially rational as defined above, but it is still open, whether it retains this property once we assume that player 1 does not know exactly player's 2 discount factor, but has only a subjective probability distribution over it.
In any case, simple as it is, Rubinsteins's model with the sequential rationality of the strategy it recommends shows us the direction to go (see also Roth 1985, Sutton 1986): devise sequentially rational bargaining strategies, and then have them tested in experiments: whether naive subjects

apply then spontaneously, and how naive subjects bargain when paired against them. This brings me to my last recommendation:

V.

5.) Once we adopt a process oriented notion of rationality, as outlined, we have to put the analysis of our subjects' bargaining behavior, which means the reconstruction of the bargaining strategies, applied by the players, into the center stage of experimental social dilemma research. The experimental design of choice for this analysis are bargaining games between a real subject and a group of computer simulated bargaining partners.

Bargaining behavior is something very reflexive. A player's present move is a response to all the previous moves of the other players, which in turn are responses to the even earlier moves by all players, and so on. Given the huge variance in these data, it seems to be practically impossible to test any non-trivial theory of bargaining in real groups with several real subjects. We can overcome this problem only, if we set up experiments in which we control the bargaining strategies of all players save one, in order to have all remaining variance, which can be observed in the bargaining sequence, caused by the step-by-step decision of this one remaining subject.

Either we have the means to train bargaining partners to such a degree, that we can be sure that they even in long bargaining sequences strictly apply a specific bargaining strategy (which has to provide rules for every contingency by the other players), which we have determined beforehand. Or - and I think, this is the obvious choice - we have all bargaining partners being simulated by a computer program save one - the one real subject. Here we can have the simulated partners play arbitrarily complicated bargaining strategies under completely controlled conditions. All the systematic variance (we can include stochastic elements in the simulated partners' strategies) in the bargaining sequence data is then due to the one real subject. We can expect a broad horizon of interesting results, unobtainable without this technique, which has the potential to dramatically contribute to the future development of our area of study.

Progress in methodology, however, must go hand in hand with progress in theory. It would be senseless to have the simulated bargaining partners apply inefficient bargaining strategies.

Once all partners in a bargaining process have the same endowment and the same interests, no bargaining strategy can be rational which is not a best reply to itself. In many aspects, however, one can expect only trivial results from a bargaining experiment in which the most rational course of action for a real subject is simply to do what the simulated bargaining partners do. On the other hand, if the best reply to what the simulated partners play is some other bargaining strategy, it easily can require a lot of intellectual effort determine what the best reply exactly is, and, even more difficult, how far other-than-best replies actually are off the mark. Such a theoretical understanding is the inevitable prerequisite for the measuring the rationality of real subjects' empirical bargaining strategies. Another problem is that the bargaining strategy which a subject applies, can never be determined absolutely exactly from the empirical sequence of bargaining moves. In general we can only derive to what class of bargaining strategy a real subjects' strategy actually belongs.

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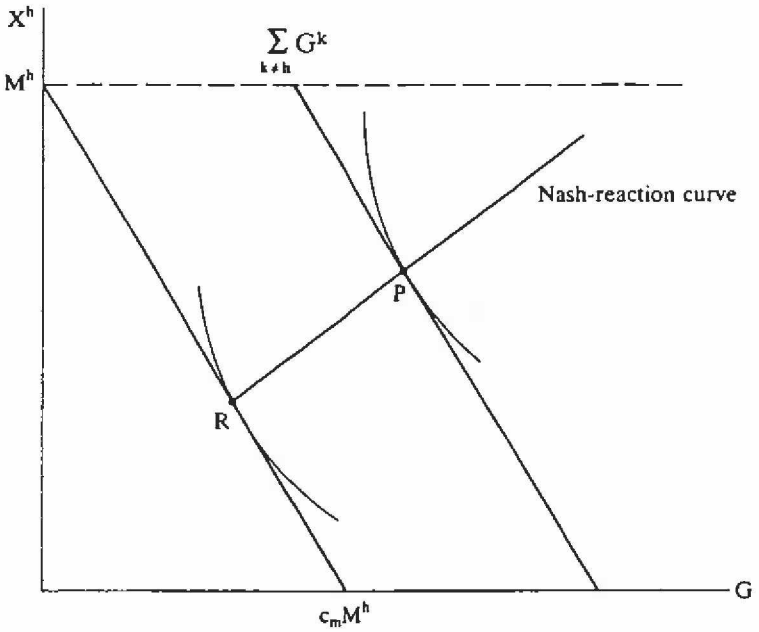

FIGURE 1. The individual Nash-reaction curve
(taken from Mueller et al. 1987)

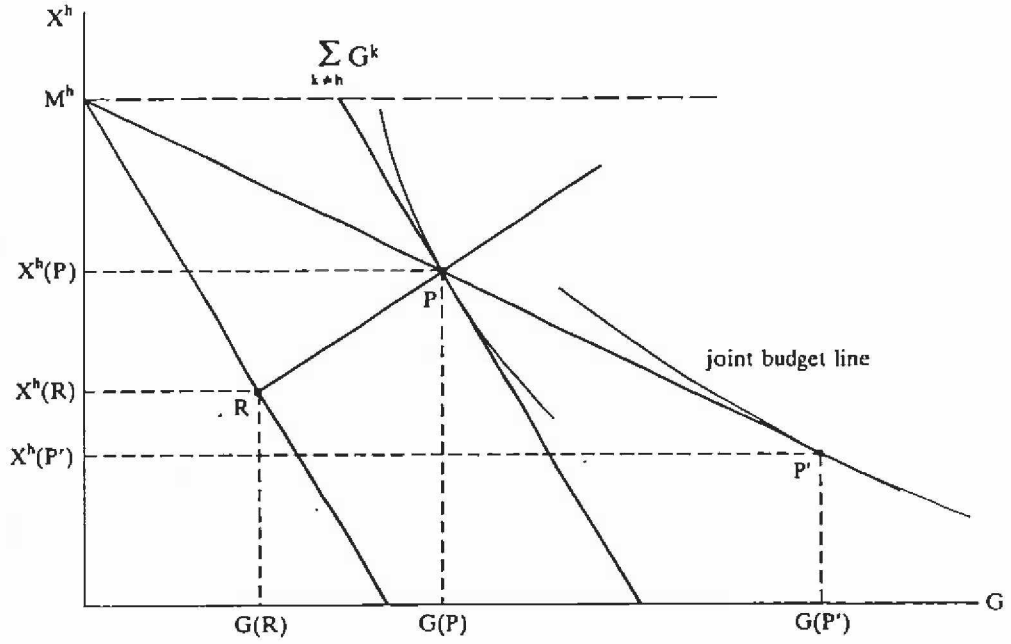

FIGURE 2. Nash-equilibrium P and social optimum P'
(taken from Mueller et al. 1987)

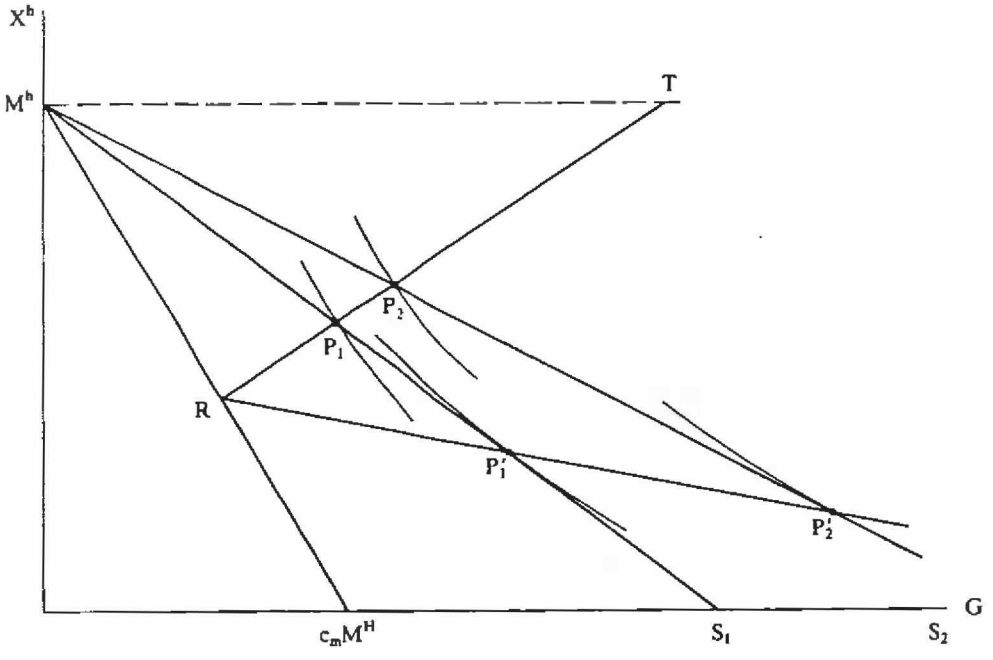

FIGURE 3. Nash-reaction curve and Group-Welfare-reaction curve (taken from Mueller et al. 1987)

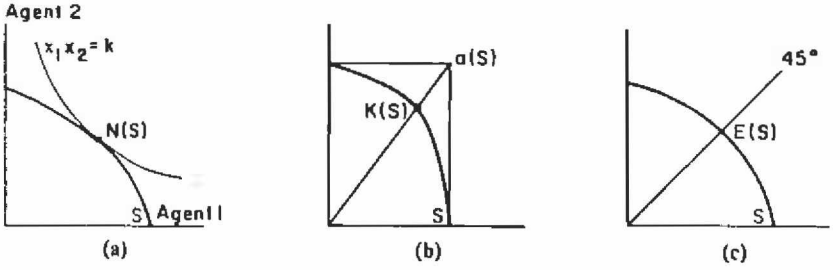

FIGURE 4.

a) Nash-solution;

b) Kalai-Smorodinsky solution;

c) Egalitarian-solution.

(taken from Thomson 1985)